



Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

TDAQ from Scientific Computing Division (FDE/SCD)

Ryan A. Rivera

2020 Snowmass TDAQ Community Meeting

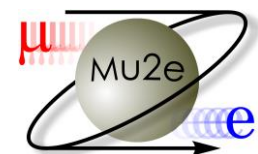
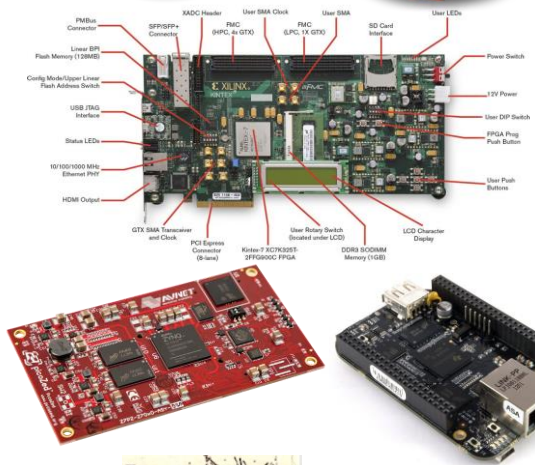
July 16, 2020

Who are we?

- **Frameworks, DAQ and Electronics** (FDE) department
 - 4 groups of 6-8 people
 - 2 software groups and 2 electrical engineering groups
- **DAQ software framework** (and analysis software framework) experience
- **Detector readout chain**, circuit board design, test stand, and test beam
- **Trigger and DAQ** project management and FPGA experience
 - L2 responsibility in Mu2e and SBN
 - Trigger and real-time machine learning FPGA implementation for CMS
 - Responsible for NOvA DAQ firmware and software

otsdaq and artdaq Data Acquisition Toolkits

- **otsdaq** is a Ready-to-Use DAQ solution aimed at test-beam, detector development, and other rapid-deployment scenarios
 - Well established web-based graphical interface for **Chrome** and **Firefox**.
 - Users implement custom functionality through plugins
 - Growing library of user plugins.
 - *otsdaq* uses *xdaq* and the *artdaq* framework under-the-hood, providing flexibility and scalability to meet evolving DAQ needs
- **artdaq** is a plugin-based DAQ toolkit, used by several experiments such as ProtoDUNE, SBN, and Mu2e
 - Flexible and scalable design allows for different detector technologies and event selection
 - Allows for data to be analyzed mid-stream for software triggers
 - *artdaq* filtering modules are compatible with the **art** analysis suite
- Full **otsdaq/artdaq/art** suite chosen for Mu2e.

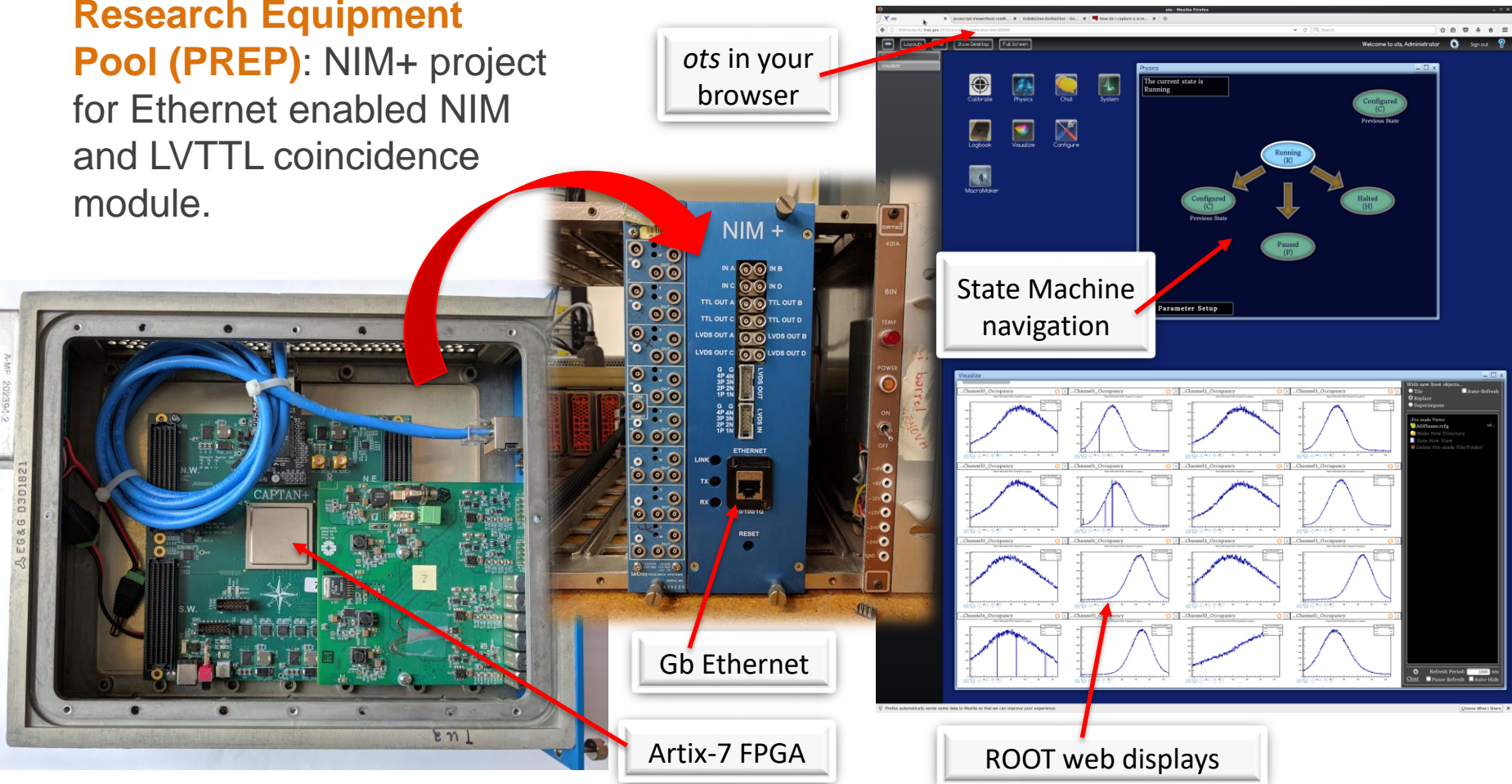


Expanding user base through test stands and test beams

- *otsdaq* used to readout Silicon Tracking Telescope, Wire Chambers, and Cerenkov
- Users fully integrated in *otsdaq*:
 - CMS Inner Tracker Europe group
 - CMS Inner Tracker USA group
 - CMS Outer Tracker Strip-Strip modules
 - CMS Outer Tracker Strip-Pixel modules
 - CMS HGCal
 - CMS Timing Endcap (USA)
 - CMS Timing Barrel (Europe)
- Users of precision tracking (and synchronized with *otsdaq*):
 - LHCb Strip detector
 - SPHENIX at RHIC GEM detectors

Other Initiatives

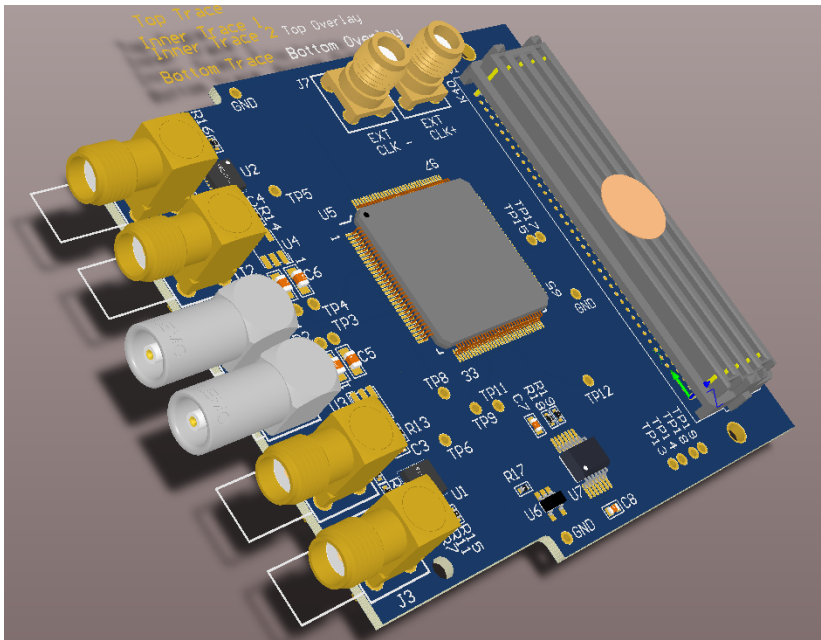
- **Modernizing the Physics Research Equipment Pool (PREP):** NIM+ project for Ethernet enabled NIM and LVTTL coincidence module.



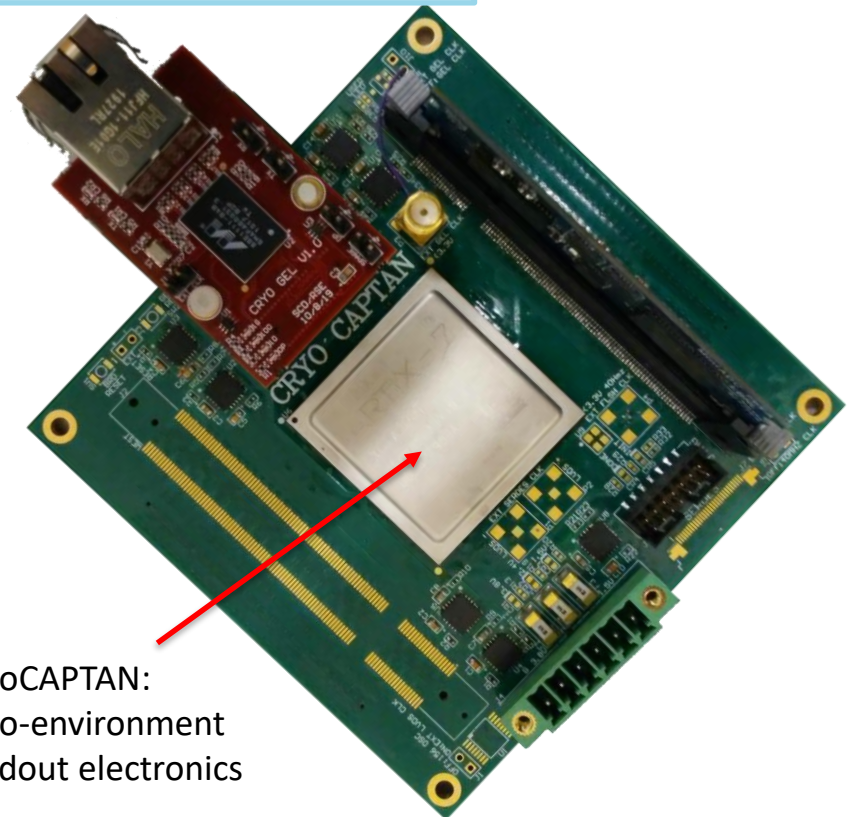
Plans for Detector Support and Modernizing Equipment

In FY20-22 add additional DAQ support for the detectors at the Fermilab Test Beam Facility (FTBF), including the Silicon Strip Telescope, Wire Chambers, and Cerenkov, including a event server for rapid-turnaround analysis.

And continue work to modernize modules available in the Physics Research Equipment Pool (PREP) for all Fermilab collaborators. Also, supporting growing demand for cold-electronics readout.



Gigabit-ADC Mezzanine Card for NIM form-factor

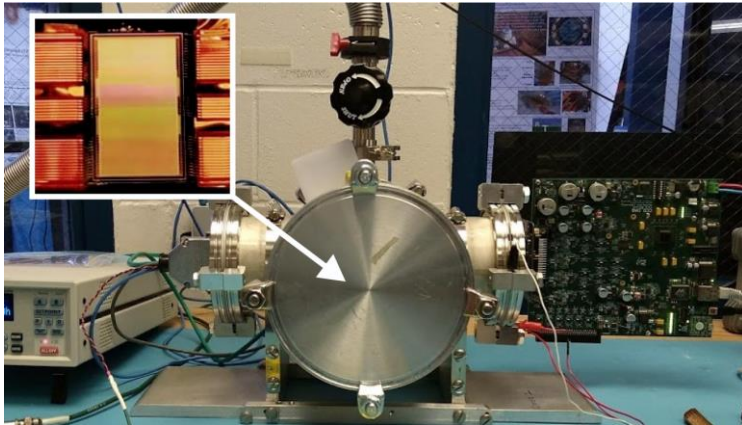


CryoCAPTAN:
Cryo-environment
readout electronics

Low-Noise Detector Readout

- LTA-QSM electronics picked as readout and DAQ for skipper CCD experiments (SENSEI, CONNIE, DM 10Kg).
 - 100 boards are in production at 10% of the cost of a commercial lower performing alternative. \$100K (LTA) vs \$1M (commercial)
- fMESSI readout being used for CMB-S4 R&D at SUBARU
- Next version of fMESSI is being developed and will cover needs for CMB-S4, ADMX, QC, and MKIDs.
- ARAPUCA photon detector for DUNE achieves 4% efficiency with active array of SIPMs

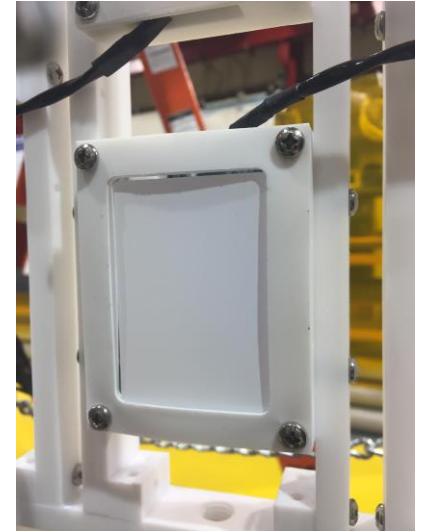
LTA-QSM for skipper CCDs



fMESSI for QC and superconducting detectors

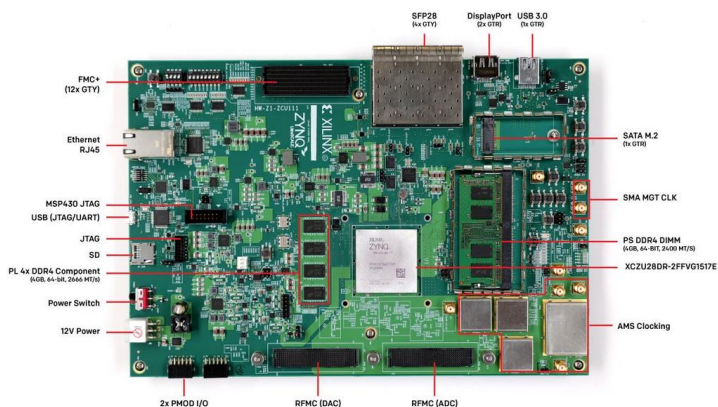
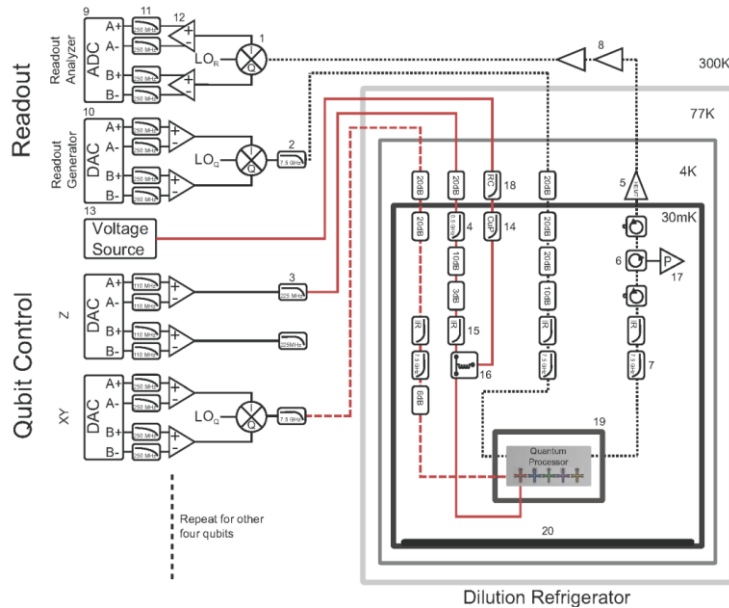


ARAPUCA (TalBo at PAB)



Superconducting quantum processor readout and control (SQC-R&C)

Gustavo Cancelo Fermilab PI for Readout and Control (DOE-QUANTIED)



FNAL hardware based on RFSoc FPGA. Used to do the measurements shown

- Fault tolerant quantum computers require a sophisticated readout and control electronics that includes RF hardware, high speed A/D and D/A electronics, FPGA signal processing, error detection and correction, flexible quantum program control, etc.
- Fermilab is leading an effort in R&C, with partners at UC and MIT.
- SQC-R&C developments have an important synergy with electronics for some of the main DOE Cosmology projects such as CMB-S4, ADMX, and MKIDs R&D.
- We are already controlling qubits (see Rabi & Ramsey oscillations).

